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DIESEL ENGINE PERFORMANCE AND EMISSION ANALYSIS USING MOSAMBI PEELPYRO OIL WITH NANO ADDITIVE PARTICLES

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ABSTRACT

An experimental study is carried out to the performance and emission characteristics of Mosambi peel pyro oil in a direct injection single cylinder diesel engine by using the Nano Rhodium Oxide (Rh_2O_3) as an additive which is in turn prepared by the ball milling process with the particle size characterised by Scanning Electron Microscope to be in the range of 100 nm. The resulting effect of the Rh_2O_3 is scrutinized in comparison with the neat diesel and the neat Mosambi peel pyro biodiesel as well. The nanoparticles added to the biodiesel minimizes the carbon deposits and aids to improvise the anti wear operation that leads to a better performance with reduced emission characteristics of the engine. The nanoparticles blended pyro oil in contrary to the neat diesel is observed to have reduced the NOx emissions up to 34% and the Unburnt hydrocarbon (UBHC) up to 40%. By releasing the energy to the fuel, Rh_2O_3 has reduced the energy consumption and enhanced the Thermal efficiency.

KEYWORDS: Nano Particles, Pyro Oil, Fuel Additive, Rhodium Oxide, Performance & Emissions

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Original Article

INTRODUCTION

The diesel engines are considered to be fuel efficient and sturdier than gasoline engines. However, they produce hazardous emissions such as oxides of nitrogen (NOx), particulates of matter, smoke, and obnoxious odor in high magnitudes. To ameliorate the performance and to reduce the emissions from the diesel engines, various techniques such as fuel modification, engine design alteration, exhaust gas treatment etc. Have been tried. Several researchers have contributed their efforts on fuel modification techniques in which some chemical reagents are incorporated along with the conventional diesel fuel One of the fuel modification techniques is the water-diesel emulsion, which comprises diesel, water, and surfactant in specific proportions. The water in the emulsion is suspended in the fuel by a suitable surfactant and does not allow the water to come into direct contact with the engine surface. Many researchers have reported on various nano-particles for diesel engine applications. In view of this, many new approaches and advances in nanotechnology are being directed to use nano-fuel as a potential secondary energy carrier. Nanoparticle blended fuels are known to exhibit significantly different thermo physical properties when compared to base fuels. At nanometers scale the surface-area to volume ratio of the particle increases considerably and this enables a larger contact surface area during the rapid oxidation process. Biodiesel is an eco-friendly renewable alternative fuel of diesel it is made by transesterification of vegetable oils and animal fat. The main feedstock for pyro oil production in India is non-edible oils obtained from plant species

such as Jatropha (Jatropha curcas), Mosambi peel (Mosambi peel pinnata) and polanga (Calophyllum in ophyllum) due to the high cost of edible oils. The natural distribution of Mosambi peels along coasts and river banks in India and also in humid tropical lowlands. Mosambi peel powder was first analyzed for its proximate composition and other properties. Mosambi peel had a high amount of crude fiber (17.6%), besides water and oil-holding capacity (2.26 and 6.82 ml/g, respectively). Mosambi peel was treated with 5% of salt and/or sodium bicarbonate overnight to remove bitterness. Mosambi peel pyro oil has the advantages of having higher Cetane number, oxygen content and it is clean. Bio-diesel was certain drawbacks of such as oil thickening at the higher temperature, higher emission, and lower performance.

EXPERIMENTAL ROUTINE

This Experimental setup is used to measure the performance and emission characteristics with a mosambi peel pyro oil and additive, on a single cylinder, direct injection diesel engine. The engine specifications are provided below in Table 1. The Experimental set up is shown below. The Exhaust gas temperatures were recorded with the help of the thermocouples. The electric dynamometer was used to record the output power. With the help of the burette and stop clock, the fuel consumption time was noted. The results are shown in the figure. Brake mean effective pressure 1 bar, 2 bars, and 3 bars are loads of the test engine.

Table 1: Engine Specification

Type	Single cylinder, four store, air cooled direct injection diesel engine
Capacity	661 CC
Bore × stroke	87.5 mm × 110 mm
Compression Ratio	18:1
Speed	1500 RPM
Rated power	3.5 kW
Injection Timing	25 BTDC
Injection Pressure	220 bar

Figure 1: Experimental Setup

RESULTS AND DISCUSSIONS

Performance Characteristics

Brake Specific Fuel Consumption

The Owing to the fact that MPO10 have lower calorific values, in order to maintain same output power we have to burn more amount of MPO10, when compared to diesel, which means that fuel consumption is more in MPO10, than in normal diesel operation. Addition of Nano-fuel additives (Rhodium Oxide), to MPO10, improves the combustion of the fuel as a result of catalytic chemical oxidation. It was observed that there was a 3% reduction in BSEC at full load conditions. The variations of BSEC are shown in Figure 2. The comparison of brake thermal efficiency for MPO10, Mosambi peel pyro oil with additive and diesel fuel with brake mean effective pressure is shown in Figure 3. Because of Lower volatility, low calorific value, higher density, and viscosity, the break thermal efficiency of the neat MPO10 is much lower compared to the neat diesel fuel. Only 18-20% of the fuel is transformed into mechanical energy and the remaining is radiated out to the atmosphere as waste heat. Because of the lower calorific value and methyl ester combustion at diffusion sizzling in the late expansion stroke the neat MPO10 has lower thermal efficiency compared to the neat diesel. In order to overcome these, Nano-fuel additives (Rhodium oxide) were added to the MPO10 and its effects were investigated. On full load operations, there was a slight enhancement in the thermal efficiency compared to the neat MPO10 this is due to the fact that metal oxide additive reduces the evaporation time and hence reduces the phenomenon of physical delay. Rhodium Oxide possessing more affinity towards the water vapor generates hydrogen and improves the fuel combustion.

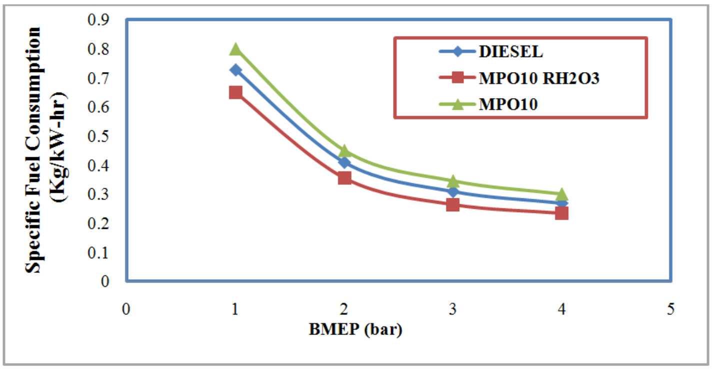

Figure 2: BMEP vs BSFC

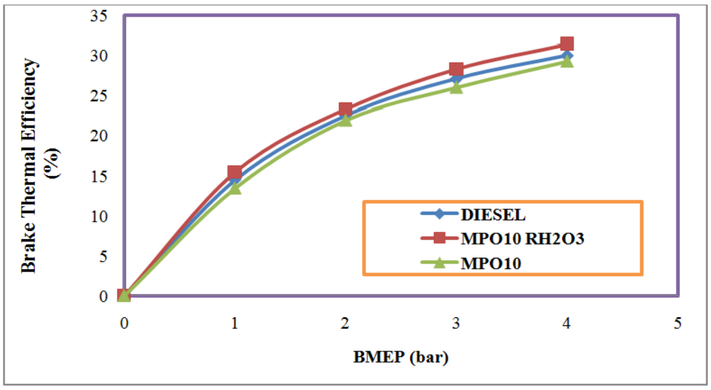

Figure 3: BMEP vs. BTE

Emission Characteristics

Hydrocarbon

The comparative study of HC emission for MPO10, MPO10 with additive and diesel fuel with brake mean effective pressure is shown below in the figure. Due to the presence of oxygen fuel bond in the MPO10 which reduces the fuel rich zone, the HC emission off MPO10 is much lower compared to the neat diesel. The fundamental reason for HC emissions is the presence of fuel-rich zone, flame quenching, desorption of lubricating oil. Addition of Nano fuel additive Rhodium oxide avoids the formation of the fuel rich zone by acting as oxygen buffer supplying lattice oxygen to the fuel. It was observed that there was a 35% reduction in HC emission on comparison with MPO10, as a corollary we can say that mixing was much better and fuel had burnt completely.

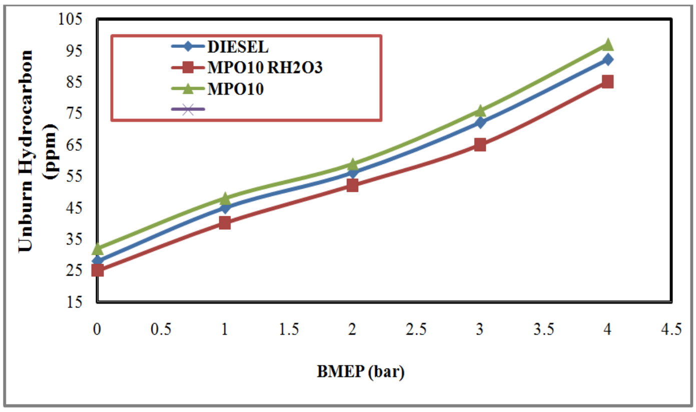

Figure 4: BMEP vs HC

Oxides of Nitrogen

The variation of NOx emission for MPO10, Mosambi peel with nano fuel additive and diesel fuel with brake mean effective pressure shown in figure 5. The fundamental reason for the formation of Nox is higher combustion temperature since the MPO10 has higher fuel bound oxygen it promotes the complete combustion and the temperatures are higher and hence Nox emissions are higher in bio-diesel combustion. Some other factors that cause Nox emissions are injection timing and combustion quality. Another reason for higher NOx emissions is the advancement of injection by 2° due to the higher bulk modulus of the MPO10. Addition of the Nano-fuel additive(Rhodium oxide) results in the Nox reduction by 31% at all load conditions as Rhodium oxide is an active single metal catalyst for Nox.

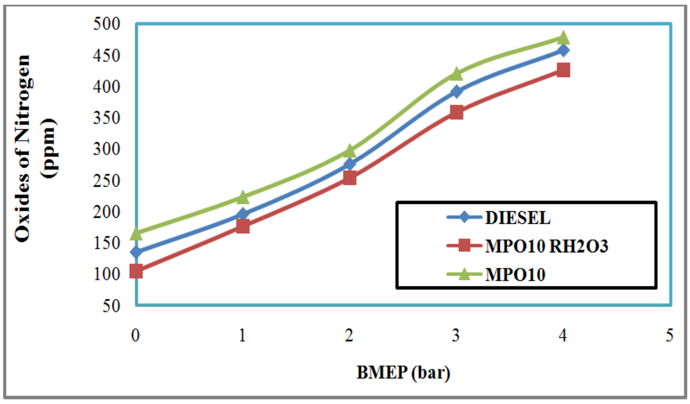

Figure 5: BMEP vs. NOx

Carbon Monoxide

Figure 6 shows the variations of carbon monoxide (CO) for MPO10, Mosambi peel with nano fuel additive and diesel fuel with brake mean effective pressure. The main reason for higher CO emission is fuel-rich combustion where the progression is Co_2 is not complete due to the lack of oxygen to support complete combustion. It was observed that there was a reduction in CO emission by 10-12% as MPO10 contains bounded oxygen to the fuel. Addition of Nano- fuel additives (Rhodium oxide) reduces Co emissions by 35%. This reduction takes place as oxygen Rhodium acts as oxygen buffer donating surface lattice oxygens for complete combustion thereby CO expansion to CO_2.

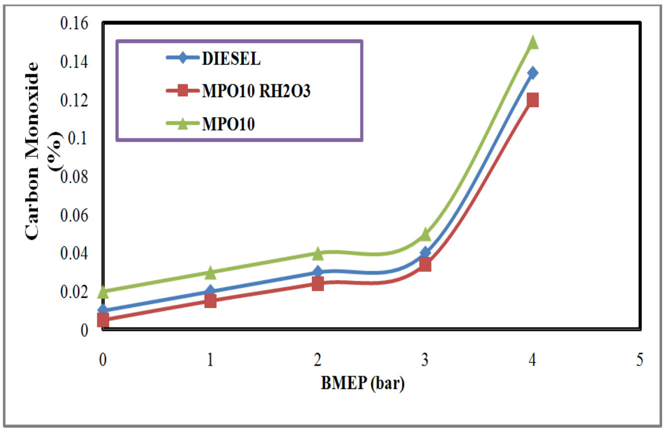

Figure 6: BMEP vs. CO

CONCLUSIONS

The performance and emission characteristics of Mosambi peel biodiesel engine are studied and based on the experimentation undergone the following conclusions can be drawn. Owing to the lower heating value of the Biodiesel, the efficiency is observed low compared to the normal diesel engine and the energy consumption in the case of Biodiesel is way too high. It is also observed that there is a comparatively significant increase in the efficiency of the biodiesel due to the addition of the nanoparticles.

- There was a considerable reduction in the HC emission by the use of MPO10 owing to its oxygen bonding, whereas when the nano particles (Rhodium oxide) were added to the MPO10, Hc emission was dropped down to 35% in comparison to the MPO10.
- Rhodium oxide which acts as an oxygen buffer donates surface lattice oxygen, thereby reducing CO emission up to 45% compared to the normal MPO10.
- When Nanoparticles were introduced in the MPO10 it was observed that there was a slight enhancement in break thermal efficiency.
- It was a known fact that MPO10 has more Nox emission when compared to diesel. But, when Nanoparticles where introduced in the MPO10, the Nox emission were observed to reduce by 31%.

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